Journal of Environmental Protection and Ecology 12, No 4, 1759–1765 (2011)

RESEARCHES REGARDING THE MIGRATION OF THE DANUBE SHAD

V. IORGA[a], V. CRISTEA[b], N. PATRICHE[a], T. PATRICHE[b], A. TROFIMOV[a], C. MOCANU[a], M. MOCANU[a], E. BOCIOC[b], M. T. COADA[b]*

[a]*Institute of Research and Development for Aquatic Ecology, Fishing and Aquaculture, 54 Portului Street, 800 211 Galati, Romania*
[b] *'Dunarea de Jos' University, 47 Domneasca Street, 800 008 Galati, Romania*
E-mail: *marian_tiberiu@yahoo.com*

Abstract. The Danube shad (*Alosa pontica* E i c h w a l d, 1838) is a migratory species having a spread area, which covers the Black Sea basin and the lower Danube river. The shad population is made up of all age classes which live, feed and spend the winter in the south-western Black Sea. A component part of the population is made up of the brood stock which migrates in the river, and another component part includes the juvenile which migrate from the Danube river into the Black Sea. The biological material resulted from the fishing carried out for scientific and industrial purpose in the Danube river was used in order to get the necessary data. The study on Danube shad migration was based on the samples defining its spread in time and space. The following parameters were entered in the records for each test sample: total length, body length, weight, sex and age (by examining scales). It is certified the hypothesis that the preferred places for reproduction of the Danube shad are mainly located between Braila and Calarasi. The length frequency has the aspect of the histogram specific to a normal distribution of an only one class, as a result of the domination of 2-year old generation, followed by the 4-year generation and the fact that the migration takes place when the specimens have reached sexual maturity, expressed by the dimensions of migration and amount of fats, necessary for energetic loss during migration. The dimensions average, after the sampling in the analysed period reflects the size of specimens that migrates at a time and not the entire population.

Keywords: the Danube shad, migration, temperature.

AIMS AND BACKGROUND

From an economic point of view, the Danube shad is extremely important for the fisheries located starting from the Danube mouths to Calarasi, due to the fact that it sometimes provides a percentage of 90% of the annual catch. It is certified the hypothesis that the preferred places for reproduction of the Danube shad are mainly located between Braila and Calarasi[1]. The statistic data on the records of the Danube shad production within the period 2007–2008 reveal a relatively favourable situation for breeding stocks (Table 1).

* For correspondence.

Table 1. Danube shad production (*Alosa pontica* E i c h w a l d, 1838) by sectors within the period 2007–2008

Year	Danube mouths – Cotu Pisicii		Cotu Pisicii – Bazias		Total	
	kg	%	kg	%	kg	%
2007	137.801	93.99	8.796	6.01	146.597	100
2008	548.065	94.31	33.070	5.69	581.135	100

During the last century, the Danube meadow, on the Romanian sector, was embankment of 53 precincts, totalling an area of 430 000 ha, through a 1200 km of dams. This almost total embankment of the Danube meadow affected the hydro-geomorphologic system and the local and regional top climates. The mentioned phenomenon accentuated under conditions of the global climate changes, when the hydro-meteorological extremes are more frequent leakage and obstruction in the riverbed of the Danube during 'high waters' periods, has become a real problem[2]. However, it has been restricted to the disappearance of the areas for natural reproduction of fish and development of juveniles. A significant example is reducing of cyprinids populations which spawn in the flooded Danube meadow, due to embankment of the meadow[3]. As a consequence, appears a restructure of biocenose, expressed in the disappearance of species and replacing them with less valuable species in the trophic chain. Regarding the importance of the hydro-climatic regimen in physiological processes of fish species, was analysed the evolution of these factors in the Bazias – Galati sector[4,5]. To put the record on the situation in the current year, have been presented data on water levels and water temperatures in 2007 and 2008.

EXPERIMENTAL

Maximum water levels were reached in the stations as follows: Tulcea, in March, April (270 cm); Galati, in April, May (484 cm); Braila, in April, May (501 cm); Cernavoda, in April (424 cm); Calarasi, in April (413 cm) (Tables 2 and 3). Flows increased during March to May have a positive influence on the development of progeny as a result of natural reproduction.

Table 2. The Danube river water levels in the year 2007

Month	Level of the Danube waters (cm)														
	Tulcea			Galati			Braila			Cernavoda			Calarasi		
	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.
I	73	109	145	122	177	235	118	176	241	–40	55	174	4	90	200
II	151	187	239	320	370	415	242	300	382	140	217	312	148	225	309
III	204	239	265	210	321	428	329	381	429	244	304	368	235	298	363
IV	131	206	275	158	192	240	154	191	243	23	69	136	50	95	156
V	97	119	151	157	206	244	152	205	246	5	81	142	34	102	162
VI	97	128	150	80	101	113	100	136	187	–59	–4	74	–15	37	110
VII	63	85	118	100	196	331	91	193	340	–79	72	263	–28	111	281
VIII	44	59	67	175	209	300	170	209	305	22	82	204	45	99	197
IX	54	118	207	360	396	417	214	328	411	115	245	354	147	248	353

Table 3. The Danube river water levels in the year 2008

Month	Level of the Danube waters (cm)														
	Tulcea			Galati			Braila			Cernavoda			Calarasi		
	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.
I	128	160	201	–198	250	310	195	254	317	61	146	232	77	153	235
II	117	168	200	–193	269	316	192	273	324	62	169	233	81	173	237
III	100	187	274	171	300	423	168	307	445	32	221	394	59	238	402
IV	273	290	315	420	448	484	428	462	501	343	390	424	327	380	413
V	206	261	314	317	396	484	320	406	501	208	300	418	203	285	397
VI	182	206	223	280	315	343	282	320	348	165	219	260	165	220	257
VII	100	134	196	160	211	309	151	209	309	10	74	157	45	99	167
VIII	132	171	216	104	263	335	201	266	337	53	138	235	75	148	241
IX	54	85	130	101	139	214	95	136	215	–83	81	–24	–43	9	102

RESULTS AND DISCUSSION

THERMAL WATER

Generally for each species are characteristic certain limits of tolerance of the temperature fluctuations and in the interval so defined, there are areas considered optimum for certain stages of exemplars development in the fisheries community (Tables 4 and 5). Considering that the optimum temperature is that value (or range of values) of temperature at which physiological processes of the exemplars of a population, involving breeding, development and reproduction are carried out with minimum loss of energy, it could be affirmed that for some aquatic live species, there a minimum value of temperature, below which they not longer develop[6]. This value is called ‘zero temperature of development’. Values above ‘zero temperature of development’, in which the organisms activity is normal are known as the ‘ef-

fective temperature'. The way in which is achieved this sum of the daily effective temperatures, depending on local climate, may influence the biological productivity of a population by increasing the number of generations in a determined period, as a result of reaching sexual maturity sooner or later[7]. For aquatic organisms and particularly for fish, the water temperature is a factor able to initiate and determine important biological processes, such as fish migration. Average temperatures in 2008 are included in the normal limits.

Table 4. Temperature of the Danube water (sector 0–370 km) in the year 2007

Month	Temperature of the Danube water (°C)														
	Tulcea			Galati			Braila			Cernavoda			Calarasi		
	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.
I	2.5	2.8	3.0	3.5	4.0	5.0	3.5	4.0	4.5	3.5	4.0	4.5	3.7	4.4	5.5
II	3.0	3.8	5.0	3.5	4.3	5.0	3.0	4.3	5.0	3.0	4.3	5.5	4.0	4.7	5.5
III	3.5	5.9	8.0	4.5	6.7	9.0	4.0	6.3	9.5	4.0	6.3	9.5	4.8	7.1	9.5
IV	8.0	10.9	15.0	9.0	11.8	15.5	9.5	11.6	15.0	9.5	11.6	15.0	9.5	11.9	15.5
V	15.0	18.1	20.5	15.0	18.5	21.5	15.0	18.3	22.0	15.0	18.3	22.0	15.0	18.2	22.0
VI	20.5	23.1	25.0	22.0	23.8	26.5	22.0	24.0	26.5	22.0	24.0	26.5	22.0	23.6	26.8
VII	26.0	26.6	28.0	26.0	26.7	27.0	26.0	26.6	27.0	26.0	26.6	27.0	25.5	26.6	27.2
VIII	24.5	25.2	28.0	24.5	25.3	27.0	24.0	25.1	27.0	24.0	25.1	27.0	23.5	25.2	27.0
IX	18.0	21.8	25.0	18.2	21.5	25.5	18.0	21.5	25.0	18.0	21.5	25.0	17.0	21.5	25.8

Table 5. Temperature of the Danube water (sector 0–370 km) in the year 2008

Month	Temperature of the Danube water (°C)														
	Tulcea			Galati			Braila			Cernavoda			Calarasi		
	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.
I	0.5	1.2	3.0	0.5	1.1	2.5	0.5	0.9	2.0	0.5	0.9	2.0	0.5	1.2	2.8
II	1.5	3.0	5.0	2.2	3.3	5.8	2.0	3.1	5.0	2.0	3.2	5.0	3.0	3.9	5.8
III	5.5	8.0	9.5	6.5	8.1	10.0	6.0	8.0	10.0	6.0	8.0	10.0	5.8	8.3	10.0
IV	9.5	12.3	15.0	9.0	11.8	15.0	10.0	11.7	15.0	10.0	11.7	15.0	9.0	11.6	14.8
V	15.0	18.5	21.5	14.0	17.8	21.0	15.0	17.6	21.0	15.0	17.6	21.0	14.8	17.6	21.5
VI	21.5	23.4	25.0	21.0	23.3	25.5	21.0	23.3	25.0	21.0	23.3	25.0	21.5	23.3	25.0
VII	24.5	26.1	27.0	23.5	25.8	26.5	25.0	26.4	27.0	25.0	26.4	27.0	24.0	25.9	26.7
VIII	24.0	24.6	25.0	23.5	25.3	26.0	25.0	25.4	26.0	23.0	25.4	26.0	24.0	25.2	26.0
IX	18.0	22.0	24.0	17.5	21.6	24.5	18.0	21.6	26.0	18.0	21.6	26.0	17.3	21.5	24.8

MIGRATION EVOLUTION

Migration in year 2008 started in the first decade of March, at a temperature of the Danube river water of 5–7°C. The size of reproducers stock is a parameter of the Danube shad population which varies from one year to another within a wide range of limits. Migration of the Danube shad took place in March–July, when

the first, respectively the last fish were caught. The maximum intensity was recorded in the second decade of April, at water temperature of 11–12°C and it was extended until July at a thermal value of 26°C. The increase of water temperature values has a decisive influence on the start and the intensity in the first half of its evolution. Migration started, increases in intensity, reaches a maximum, with the spring flooding of the Danube waters, another factor with major importance in the migration evolution. The hydro-meteorological factors influence in time and space the migration evolution, without determining the extent of migrant stock. Distribution of catches on the arms of the Danube indicates that the majority of exemplars of the Danube shad migrate to the Saint George arm, to the Tulcea arm and then in Danube. Migration to the Chilia arm, in relation with Romanian capture, had a slight intensity, but the Ukrainian capture in the Chilia arm is sometimes similar to that in the St. George arm (Table 2).

Table 6. Dynamics of the Danube shad migration

Chilia arm		Saint George		Sulina		Danube		Total	
kg	%	kg	%	kg	%	kg	%	kg	%
3428.7	0.59	452994.7	77.95	69968.7	12.04	54742.9	9.42	581135	100

STRUCTURE BY AGE AND SEX

The demographic structure was examined based on the sample jointly collected in April–July. In the migration of year 2008, dominate the exemplars of 2-year old (24.6%), followed by the 4-year old ones (20.8%), respectively 6-year old (19.2%). In the examined samples, there were identified 7-year old fish, like in the previous years, but it is possible to exist in an extremely reduced number. The ratio of sexes (M/F) was a sub-unit one, indicating a slight domination of males (M/F = 1.05), which are prevailing in stocks in the examined period. The males are prevailing in stocks before the start of migration and to the end of migration the females dominate. It was found that body mass of males is reduced, and of the females increase with ageing.

STRUCTURE BY AGE AND DIMENSIONS

The length frequency has the aspect of the histogram specific to a normal distribution of an only one class, as a result of the domination of 2-year old generation, followed by the 4-year old and the fact that the migration takes place when the specimens have reached sexual maturity, expressed by the dimensions of migration and amount of fats, necessary for energetic loss during migration. The average dimensions, after the sampling in analysed period (Table 7) reflect the size of specimens that migrate at a time and not the entire population.

Table 7. Structure by age and dimensions

Age (years)	No of fish	Dimensions	Min.	Med.	Max.	S
2	227	LT	20.1	20.7	24	0.627
		LS	17	17.5	18.5	0.529
		W	93	105.3	141	9.52
3	155	LT	21.3	26.7	33.2	3.43
		LS	15.5	22.5	28	3.3
		W	110	246.7	365	78.01
4	193	LT	26.2	32.4	37	2.69
		LS	22.4	27.5	32.7	2.45
		W	130	314.8	371	49.27
5	172	LT	25.6	34.3	38.1	3.38
		LS	23	28.8	33.5	3.26
		W	196.1	330.0	381	42.8
6	178	LT	31.3	37.4	43	1.95
		LS	27.5	32.4	36	1.78
		W	311	418.8	451	39.29

LT – total length (cm); LS – standard length (cm); W – weight (g); S – standard deviation.

CONCLUSIONS

Generally, after reaching 2-year age, migration takes place if the fish reached the maturation stage, the migratory brood presenting a slight dimorphism, the females were being bigger in size than the males of the same age. The brood stock in 2008 was represented by 5 generations. For the sustainable exploitation it is recommended the protection of a fraction of the brood stock of the Danube shad from the mouth of the Danube river to the spawning areas by increasing the period of prohibition of fishing.

Acknowledgements. Researches were conducted in the project POSDRU No 6/1.5/S/15 'Management System of Scholarships for Ph. D. Students No 6583 – SIMBAD' and 'Efficiency of Ph. D. Students Activity in Doctoral Schools No 61445 – EFFICIENT', funded by the European Union and the Romanian government. The authors thank the management staff of the project for their financial support.

REFERENCES

1. N. BACALBASA-DOBROVICI: Priority of Studies on Preserving Migratory Fish Species in Low Danube. C. G. S. Danube Delta Institute Bulletin (Tulcea), **1**, 28 (1995).
2. A. BANU: Limnology of Romanian Sector of Danube River. Academy Publishing House, Bucharest, 1967.

3. P. BANARASCU: Romanian Fauna – Pisces Osteichthyes. Vol. XIII. Academy Publishing House, Bucharest, 1964.
4. A. CIOLAC: Fish Fauna Structure in Low Danube River. Moldavian Sciences Academy, Kishinev, 1995, p. 64.
5. A. CIOLAC: Ecology and Fishing in before-Danube Delta Sector of Danube River. Pax Aura Mundi Publishing House, Galati, 1998.
6. M. C. LUCAS, E. BARAS: Migration of Freshwater Fishes. Blackwell Science Ltd., New York, 2001.
7. A. CIOLAC, N. PATRICHE: Structure of Danube Shad (*Alosa pontica* E i c h w a l d, 1838). Applied Ecology and Environmental Research, **2** (2), 53 (1994).

Received 27 May 2011
Revised 21 June 2011